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Smart hybrid nanostructures for cancer treatment

N.D. Thorat[1], C. Silien[2,3], S.A.M. Tofail[2,3], J. Bauer[1]

[1]*Department of Bioengineering, Faculty of Fundamental Problems of Technology, Wroclaw University of Science and Technology, 50-370 Wrocław*

[2]*Department of Physics, University of Limerick, Limerick, V94 T9PX, Ireland*

[3]*Bernal Institute, University of Limerick, Limerick, V94 T9PX, Ireland*

In last decade, the smart hybrid nanostructures (SHN) have been proposed for the theranostic of various types of human cancers. This includes technologies that enable simultaneous diagnosis, primary and if necessary secondary treatment, as well as monitoring of the therapy outcomes. Numerous SHN are nowadays used as remotely triggered modalities, such as organic and inorganic nanostructures, organic-inorganic conjugates, polymer micelles, liposomes etc. These SHN can be administrated directly or indirectly into tumors and respond to different external physical stimuli e.g. ultraviolet, visible or near-infrared light, radiofrequency waves, X-ray, alternating magnetic field or ultrasound waves. Among of all SHN, the nanocomposites that may be stimulated by light and used as remote triggers to exert anti-tumor activity through irradiation are of particular interest. Currently, the light-mediated cancer theranostic is more likely to apply near infrared radiation (NIR) than ultraviolet (UV) or visible light (VIS), which is related to greater and deeper NIR penetration into the tissues and less scattering, however the exact light used depends on the type of the nanomaterial and therapeutic modality [1, 2].

Light-stimulated nanotheranostics are usually combined with various types of therapies, such as photodynamic therapy (PDT), photothermal therapy (PTT), photo-triggered chemotherapeutics (PTCH) or two-photon triggered therapy (TPTT) [3]. They are frequently integrated into a single multifunctional nanoplatform, that may use different light triggered co-therapy modalities by designing smart multifunctional materials that combine different types of imaging and therapeutic agents. A number of new strategies have recently been developed to enhance the overall therapeutic effect of SHN, e.g. oxygen self-enriching photodynamic therapy (Oxy-PDT) where the photosensitizer is stuffed into perfluorocarbon nanodroplets to optimize tumor oxygenation or decorating platinum nanozymes on photosensitizer integrated metal organic frameworks (MOFs) to enhance PDT. New methods of increasing light penetration into tissues are also being tested, such as wireless photonic activation, which enables on-demand light excitation of photosensitizers for therapeutic dosimetry. On the contrary, in case of sensitive human organs the wireless systems for metronomic cancer treatment (long-term low-dose PDT) are proposed to offer an alternative way of tumors treatment. Correspondingly, the innovative optical technologies, that provide more efficient light penetration into deeply located tissues with much less attenuation using new transparency regions NIR-III (1600-1870nm) and NIR-IV (2100-2300 nm) are developed [4, 5].

Concluding, the current generation of tumor theranostic strategies seek to strengthen both, therapy and diagnosis using multifunctional smart hybrid nanostructures coupled with minimally invasive biomedical devices that maximize the permeability of the drug to the tumor and interaction with applied physical stimuli to effectively treat cancers.

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